

APPLICATION NO. 10/772,597

INVENTION: Decisioning rules for turbo and convolutional decoding

INVENTORS: Urbain A. von der Embse

Clean version of how the CLAIMS will read

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## CLAIMS

WHAT IS CLAIMED IS:

10        Claim 1. (currently amended) A method for performing a new turbo decoding algorithm using a-posteriori probability  $p(s, s' | y)$  in equations (13) for defining the maximum a-posteriori probability MAP, comprising::

using a new statistical definition of the MAP logarithm

15        likelihood ratio  $L(d(k) | y)$  in equations (18)

$$L(d(k) | y) = \ln[ \sum_{(s, s' | d(k)=+1)} p(s, s' | y) ] \\ - \ln[ \sum_{(s, s' | d(k)=-1)} p(s, s' | y) ]$$

20        equal to the natural logarithm of the ratio of the a-posteriori probability  $p(s, s' | y)$  summed over all state transitions  $s' \rightarrow s$  corresponding to the transmitted data  $d(k)=1$  to the  $p(s, s' | y)$  summed over all state transitions  $s' \rightarrow s$  corresponding to the transmitted data  $d(k)=0$ ,

25        using a factorization of the a-posteriori probability  $p(s, s' | y)$  in equations 13 into the product of the a-posteriori probabilities

$$p(s, s' | y) = p(s | s', y(k)) p(s | y(j > k)) p(s' | y(j < k));$$

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using a turbo decoding forward recursion equation

$$p(s | y(j < k), y(k)) = \sum_{\text{all } s'} p(s | s', y(k)) p(s' | y(j < k))$$

for evaluating said a-posteriori probability  $p(s'|y(j < k))$  in equations 14 using  $p(s|s', y(k))$  as the state transition a-posteriori probability of the trellis transition path  $s' \rightarrow s$  to the new state  $s$  at  $k$  from the previous state  $s'$  at  $k-1$  and given the observed symbol  $y(k)$  to update these recursions for the assumed value of the user data bits  $d(k)$  equivalent to the transmitted symbol  $x(k)$  which is the modulated symbol corresponding to  $d(k)$ ,

10 using a turbo decoding backward recursion equation

$$p(s'|y(j > k-1)) = \sum_{\text{all } s} p(s|y(j > k)) p(s'|s, y(k))$$

for evaluating the a-posterior probability  $p(s|y(j > k))$  in equations 15 using said  $p(s'|s, y(k)) = p(s|s', y(k))$  as the state transition a-posteriori probability of the trellis transition path evaluating the natural logarithm of the state transition a-posteriori probability  $p(s|s', y(k)) = p(s'|s, y(k))$  equal to the new decisioning metric  $DX$  in equations 11, 16, defined by equation

$$\begin{aligned} \ln[p(s|s', y(k))] &= \ln[p(s'|s, y(k))] \\ &= \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + p(d(k)) \\ &= DX \end{aligned}$$

25 wherein  $p$  is the natural logarithm  $\ln$  of  $p$ ,  $x^*$  is the complex conjugate of  $x$ , and  $\ln[o]$  is the natural logarithm of  $[o]$ ,

whereby said new state transition probabilities in said MAP

30 equations use said  $DX$  linear in  $y(k)$  in place of the current use of the maximum likelihood decisioning metric  $DM = [-|y(k) - x(k)|^2/2\sigma^2]$  which is a quadratic function of  $y(k)$ ,

whereby said MAP turbo decoding algorithms provide some  
of the performance improvements demonstrated in FIG. 5,6  
using said DX, and

whereby this new a-posteriori mathematical framework enables  
5 said MAP turbo decoding algorithms to be restructured and  
to determine the intrinsic information as a function of  
said DX linear in said  $y(k)$ .

10 Claim 2. (currently amended) A method for performing a new  
convolutional decoding algorithm using the MAP a-posteriori  
probability  $p(s,s'|y)$  in equations 13, comprising::

using a new maximum a-posteriori principle which maximizes the  
a-posteriori probability  $p(x|y)$  of the transmitted symbol  
15  $x$  given the received symbol  $y$  to replace the current  
maximum likelihood principle which maximizes the likelihood  
probability  $p(y|x)$  of  $y$  given  $x$  for deriving the forward  
and the backward recursive equations to implement  
convolutional decoding,

20 using the factorization of the a-posteriori probability  
 $p(s,s'|y)$  in equations 13 into the product of said a-  
posteriori probabilities  $p(s'|y(j < k))$ ,  $p(s|s',y(k))$ ,  
 $p(s|y(j > k))$  to identify the convolutional decoding forward  
state metric  $a_{k-1}(s')$ , backward state metric  $b_k(s)$ , and state  
25 transition metric  $p_k(s|s')$  as the a-posteriori probability  
factors

$$\begin{aligned} p_k(s|s') &= p(s|s',y(k)) \\ b_k(s) &= p(s|y(j > k)) \\ 30 \quad a_{k-1}(s') &= p(s'|y(j < k)), \end{aligned}$$

using a convolutional decoding forward recursion equation in  
equations 14 for evaluating said a-posteriori probability  
 $a_k(s)=p(s|y(j < k),y(k))$  using said  $p_k(s|s')=p(s|s',y(k))$  as  
35 said state transition probability of the trellis transition

path  $s' \rightarrow s$  to the new state  $s$  at  $k$  from the previous state  $s'$  at  $k-1$ ,

using a convolutional decoding backward recursion equation in equations 15 for evaluating said a-posteriori probability  $b_k(s) = p(s|y(j > k))$  using said  $p_k(s'|s) = p(s'|s, y(k))$  as said state transition probability of the trellis transition path  $s \rightarrow s'$  to the new state  $s'$  at  $k-1$  from the previous state  $s$  at  $k$ ,

evaluating the natural logarithm of said state transition

a-posteriori probabilities

$$\begin{aligned} \ln[p_k(s'|s)] &= \ln[p(s'|s, y(k))] \\ &= \ln[p(s|s', y(k))] \\ &= \ln[p_k(s|s')] \\ &= DX \end{aligned}$$

equal to the new decisioning metric  $DX$  in equations 16, and

implementing said convolutional decoding algorithms to

obtain some of the performance improvements demonstrated in FIG. 5, 6 using said  $DX$ .

Claim 3. (currently amended) Wherein in claim 2 a method for implementing the new convolutional decoding recursive equations, said method comprising:

implementing in equations 14 a forward recursion equation

for evaluating the natural logarithm,  $\underline{a}_k$ , of  $a_k$  using the natural logarithm of the state transition a-posteriori probability  $p_k = \ln[p(s|s', y(k))]$  of the trellis transition path  $s' \rightarrow s$  to the new state  $s$  at  $k$  from the previous state  $s'$  at  $k-1$ , which is equation

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + p_k(s|s')]$$

$$\begin{aligned}
&= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')] \\
&= \max_{s'} [\underline{a}_{k-1}(s') + \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]
\end{aligned}$$

wherein said  $DX(s|s') = \underline{p}_k(s|s') = \underline{p}_k(s'|s) = DX(s'|s) = DX$  is the  
 5 new decisioning metric, and  
 implementing in equations 15 a backward recursion equation  
 for evaluating the natural logarithm,  $\underline{b}_k$ , of  $b_k$  using  
 the natural logarithm of said state transition a-posteriori  
 probability  $\underline{p}_k = \ln[p(s'|s, y(k))] = \ln[p(s|s', y(k))]$  of the  
 10 trellis transition path  $s \rightarrow s'$  to the new state  $s'$  at  $k-1$  and  
 is equation

$$\underline{b}_{k-1}(s') = \max_s [\underline{b}_k(s) + DX(s'|s)].$$

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